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Diverticulosis and Diverticulitis

CLAUDE E. WELCH

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MONTHLY CLINICAL MONOGRAPHS ON CURRENT MEDICAL PROBLEMS

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Diverticulosis and Diverticulitis

CLAUDE E. WELCH

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Claude E. Welch

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DIVERTICULA may be defined as pouches that arise from the lumen of a viscus and extend outside the normal level of the wall. They are subdivided into two groups—the congenital that are present at birth, and the acquired that develop later in life. When diverticula are frequent in any segment of the intestinal tract, the term diverticulosis is applied. Inflammation arising in the wall of these pouches is known as diverticulitis. While diverticula may arise from any hollow viscus, in this monograph discussion will be limited to those which arise from the digestive tract, including pharynx, esophagus, stomach, intestine and colon.

The differentiation of diverticulosis and diverticulitis is easy for the pathologist but may be difficult for the physician. The distinction usually is made on a clinical basis, assuming that diverticulosis is asymptomatic. When symptoms occur, diverticulitis is presumed to be present.

Although all types of diverticula of the digestive tract will be discussed, by far the most frequent and important arise from the colon. The major portion of the discussion, therefore, will be devoted to diverticulosis and diverticulitis of the colon.

DIVERTICULA IN UPPER DIGESTIVE TRACT

Diverticula of the Esophagus

Two types of diverticula of the esophagus are distinguished —the true, or pulsion, diverticula, which are believed to arise

because of increased tension within the esophagus, and false, or pseudo, diverticula that form from traction on the esophageal wall adherent to an inflammatory process.

The false diverticula nearly always appear in the mid-esophagus, usually adhering to tuberculous lymph nodes. They are nearly always asymptomatic and require no treatment. Sweet has noted that occasionally a tracheo-esophageal fistula may occur, if a caseous lymph node ulcerates into both organs; in this instance, surgical repair will be necessary.

True diverticula occur either at the pharyngo-esophageal junction or just above the diaphragm. The former are by far the more common.

The pharyngo-esophageal, or Zenker's, diverticula arise from the posterior pharyngeal wall just above the cricopharyngeus muscle. As they enlarge, they descend and finally present usually in the left side of the neck, although less frequently they may appear on the right.

SYMPTOMS.—Symptoms vary depending on the size of the sac. Food collects and stagnates in the diverticulum. Dysphagia, regurgitation of the foul contents and aspiration into the trachea occur. Cough and loss of weight follow. When the diverticulum is full of gas, gurgling can be heard. The foul odor arising from decomposed food may produce intense halitosis—the most prominent symptom.

TREATMENT.—At times the patient is able to empty the diverticulum adequately by massage and thus refuses treatment. However, because the sac will increase steadily in size, surgical excision always is desirable. At present, this can be accomplished easily and safely in most cases by a one-stage excision and closure of the defect in two layers.

In the past, before antibiotic protection was available, one-stage operations occasionally were followed by perforation of the suture line, descending infection, mediastinitis and death. For this reason, the two-stage operation formerly was popular and still may be advisable in certain poor-risk patients whose diverticula have large necks. At the first stage, the diverticulum is mobilized. This dissection seals off the open-tissue planes. At the second stage, a week later, the sac again is exposed, excised and the neck closed. Any secondary infection will be confined to the operative field and will not be fatal.

Diverticula of the lower esophagus are found just above the diaphragm. They are not common, but they are serious lesions, since they lead to dysphagia, regurgitation of food, subster-

nal or back pain and, in late cases, loss of weight. They should be treated by surgical excision.

Diverticula of the Stomach

Gastric diverticula are rare, occurring uniformly near the cardia on either wall of the stomach close to the lesser curvature. They may be asymptomatic, but symptoms suggestive of gastric ulcer arise when the diverticula become inflamed or retain food debris. Under these circumstances surgical excision is indicated.

Diverticula of the Duodenum

Diverticula of the duodenum are extremely common. According to Priestley and Judd, they can be demonstrated in 14-22% of all careful autopsies.

Two types of diverticula should be distinguished—true diverticulum and pseudodiverticulum. In nearly every instance the pseudodiverticulum is secondary to contracture and fibrosis due to a chronic duodenal ulcer. These pockets are found just distal to the pylorus and include all coats of the duodenal wall. They complicate gastric resection for ulcer, but otherwise are of no significance.

The true diverticula are herniations of mucosa and of the muscularis mucosa through the muscle wall. Their walls, therefore, are extremely thin, making them difficult to identify. They occur on the mesenteric margin of the duodenum, are most common in the descending portion close to the ampulla of Vater and tend to be imbedded in the head of the pancreas.

Symptoms.—Although patients with duodenal diverticula may complain of epigastric symptoms similar to those of duodenal ulcer, it is uncommon to obtain relief from symptoms by removal of diverticula. In some instances, impaction of food debris and the complications of diverticulitis occur, namely, perforation, hemorrhage or obstruction of the common duct.

It must be admitted that it is almost impossible to tell whether symptoms arise from such a diverticulum. Epigastric pain and fullness associated with nausea and relieved by belching are considered the usual symptoms. If the sac as outlined by barium shows a narrow neck, and the barium is retained for 24 hours, it follows that the stage is set for the retention of food debris and diverticulitis. Still, even when

excision is advised for this reason, results are not always satisfactory.

TREATMENT.—When diverticula are associated with epigastric symptoms, medical treatment is indicated, similar to that of ulcer therapy—a bland diet, small frequent feedings, antispasmodics and antacids, omission of tobacco, alcohol and caffeine.

Surgical therapy is indicated, if complications referable to the diverticula occur or if, after thorough medical therapy, the internist decides no relief has been obtained. So that no one will be too sanguine about results, it may be well to summarize the experiences of two clinics.

Waugh reported 20 operations for duodenal diverticula at the Mayo Clinic. Of a total of 525 patients, 2 of the 20 operated on died following surgery and less than half who had a radical operation had a satisfactory recovery.

Cattell and Mudge believe that removal of duodenal diverticula is indicated in less than 5% of cases. Of the 25 patients operated on, 20 had diverticula in the second portion of the duodenum. Two patients died of pancreatitis. Of the 17 cases in which diverticulectomy alone was performed, results were excellent in 9, fair in 3 and poor in 5.

MECKEL'S DIVERTICULA

Remnants of the vitello-intestinal duct persist beyond embryonic life in about 2% of all people. Named for the man who first described them in 1815, they are known as Meckel's diverticula, and represent the prime example of congenital diverticula. Depending on the portion of the duct that persists, there are several possible abnormal varieties. The diverticulum may exist alone or it may be attached to the umbilicus by a fibrous cord. The entire duct may persist so that an intestinal fistula is present, draining through the umbilicus. The proximal portion of the duct may atrophy but the distal remains, forming an umbilical cyst.

The diverticulum is found about 20 inches above the ileocecal valve in infants and about 3 feet above in adults. It contains all the normal coats of the bowel. In addition, gastric mucosa is frequent, so that peptic ulceration of adjacent intestinal mucosa occurs. Other aberrant tissue may be present, and from this malignant tumors of various types may arise.

SYMPTOMS.—Symptoms vary according to the pathology present. The most important are:

1. *Hemorrhage.* Secondary to peptic ulceration of bowel mucosa, massive hemorrhage is a common symptom, occurring particularly in infants. Lanman has noted that in 31 patients with Meckel's diverticula, massive hemorrhage was the presenting symptom in 10, occurring in 8 within the first year. Among adults, nearly all patients with aberrant gastric mucosa will have been weeded out, so that bleeding as a symptom becomes progressively less common.

2. *Intestinal obstruction.* This develops for numerous reasons. Bands attached to the diverticulum, attachment of the diverticulum to adjacent viscera, and intussusception are the common mechanisms. The symptoms are those of intestinal obstruction, namely, upper abdominal cramps, followed by nausea, vomiting, obstipation and distention. While obstruction occurs at all ages, it is by far the most common complication encountered in adults. The presence of a Meckel's diverticulum may be suspected in young adults who develop intestinal obstruction without having had previous abdominal surgery.

3. *Diverticulitis.* Acute inflammation of the diverticulum may occur at any age. Signs and symptoms closely resemble those of appendicitis, although the point of maximum tenderness tends to be located in the midline or slightly to the left in the lower abdomen.

4. *An umbilical fecal fistula* present since birth is diagnostic of a persistent vitello-intestinal duct.

It should be emphasized that diagnosis must be made on purely clinical grounds. Laboratory studies offer little information beyond that of the presence of blood in the stool or, in cases of acute inflammation, of leukocytosis. The diverticulum can be demonstrated by x-ray only in most unusual cases, although rarely it will fill and be outlined clearly after a barium meal.

TREATMENT.—The treatment is surgical. Diverticula of this type are so prone to complications that, in general terms, they should be removed whenever they are encountered at laparotomy, provided no contraindication to this additional surgery exists. In particular, the terminal ileum should be examined in every patient operated on for appendicitis unless an abscess or peritonitis makes this further exposure unwise.

In most instances diverticula can be removed easily in an oblique fashion, closing the intestinal defect in such a way that the lumen is not constricted. In some instances the segment of intestine from which the diverticulum arises must be

resected. Indications for this procedure include gangrenous intestine, induration in the intestinal wall adjacent to the diverticulum, suggesting peptic ileitis in this area, or the presence of a diverticulum so large that the lumen of the intestine will be compromised by closure after simple diverticulectomy. It should be emphasized that the entire diverticulum must be removed, since peptic ulcers tend to occur at its base.

Other Diverticula of Jejunum and Ileum

Diverticulosis of the jejunum or ileum is uncommon but occasionally may be extensive. Widespread diverticulosis may be associated with a deficiency syndrome. Generally, however, diverticula are asymptomatic unless the complications of perforation, obstruction or hemorrhage occur. Perforation is likely to be due to foreign body retention. Surgical therapy is required only for these complications.

Diverticula of the Appendix

Diverticulosis of the appendix is a pathologic rarity that has no clinical significance.

DIVERTICULOSIS AND DIVERTICULITIS OF THE COLON

Theories of pathogenesis.—Congenital diverticula of the colon are uncommon; they occur as solitary diverticula of the cecum and are unsuspected until secondary inflammation develops. On pathologic section, they are distinguished by the presence of all coats of the bowel wall.

Acquired diverticula appear in adults and become more numerous with age. They therefore form one of the degenerative diseases, although the reason for their appearance is not clear. Several factors may play a role.

The theory most widely accepted is that first suggested by Klebs, who believed that traction on the wall of the colon at the site of perforation by the mesenteric vessels was the main factor. In these areas, the wall of the bowel, weakened by the vessels, would tend to herniate, producing diverticula. This theory is borne out in experiments by Noer, who injected the mesenteric vessels with liquid latex and found on cleared specimens that the diverticula were concentrated at the points of blood-vessel entry. This cannot be the only cause, however,

because some diverticula develop on the antimesenteric margin of the colon.

A definite hereditary influence is noted in some cases. Schlotthauer, for example, reported 7 cases in a family of 9.

The great predilection of diverticula to develop in the sigmoid has led to several theories concerning their origin. At this level, the gut is somewhat narrower than elsewhere and is often distended as a reservoir for firm feces. On the basis that constipation and high roughage diets aggravate the symptoms of diverticulitis, or are instrumental in converting diverticulosis into diverticulitis, it would seem logical to suppose that the same factors were at work in the initial formation of these diverticula.

However, these suppositions are difficult to prove. Constipation, or increased abdominal pressure induced by straining at stool, appears to be equally common in patients with or without diverticula. Likewise, the influence of diet is difficult to evaluate. For instance, Carlson and Hoelzel found that in experimental rats low-residue diets favored the development of colonic diverticula whereas the addition of bulk-forming material, such as psyllium husks, prevented them. They suggested that the mechanism involved might be the production of higher intracolonic pressure due to tonic contraction of the bowel in animals fed low-roughage diets.

The role of tonic contraction of the colon is also difficult to evaluate. The muscular wall of the colon often is unusually thick, not only at the site of the diverticulitis area, but also proximal to that area. Furthermore, the colon proximal to the diverticulitis is not so easily distensible as normal colon or as that proximal to an area of cancer. These clinical observations suggest that tonic contractions of the colon may play a role and may explain the value of antispasmodics in treatment.

Inasmuch as the disease appears in older people, it has been suggested that obesity favors tissue degeneration and thus weakens the wall of the colon, particularly in the region of the epiploic appendages. However, statistical studies have not shown any clear relation between obesity and diverticulosis.

Sex is not a factor in the development of the disease, since it occurs almost equally in males and females.

INCIDENCE.—The incidence of diverticulosis among the general population is not known, although statistics should be available after study of a sufficient number of barium enemas administered to asymptomatic persons in cancer detection centers.

The incidence in hospital patients may be determined either by barium enema examination or by autopsy. In either case, it is clear that the more zealous the investigator, the more diverticula will be noted. Now that the clinical spotlight is focused more sharply on diverticulosis, it might be expected that a higher incidence would be reported now than was observed formerly. It also may be expected that routine barium enema examinations now are more accurate than are routine autopsies, since diverticula nearly always are found readily by the radiologist, but require most diligent search by the pathologist. Again, hospital patients are symptomatic. Theoretically, more diverticula will exist in them than in people generally. Furthermore, persons examined by barium enema are more likely to have symptoms referable to the colon. Consequently, hospital patients receiving barium enemas should show the highest incidence of diverticulosis. Finally, since more people live longer, the more recent the study the greater the number of diverticula will be observed. These are reservations to be made in considering some published reports.

In a check of 2,000 consecutive barium enemas given at Massachusetts General Hospital during 1951-1953, Allen, Donaldson and I found almost no instances of diverticulosis or diverticulitis in patients under 35. From that age on there was a steady increase in the frequency of the disease, so that, at 85, diverticula were present in approximately two thirds of patients examined. The incidence of diverticulitis, likewise, showed a steady rise. After 60, about one fifth of all patients with diverticulosis, when x-rayed, showed evidence of diverticulitis, whereas in the ninth decade the ratio had increased to one third. Considering the entire group, one or more diverticula were observed in a third of all patients who had barium enemas, and diverticulitis in 8.9%. This incidence is distinctly higher than that noted in several other reports. For example, in 1949 Grout reported that 8% of 2,179 barium enemas in the Sheffield Royal Hospital showed diverticulosis, whereas in 1947 Pemberton *et al.* found an 8.5% incidence of diverticulosis in 47,000 barium enemas at the Mayo Clinic, with diverticulitis present in only 15% of diverticulosis cases.

In autopsy studies, Ochsner and Bargen, in 1935, found diverticulosis in 7% of a series of autopsies at the Mayo Clinic. Morton, in 1946, found diverticulosis in 6.5% of 8,500 autopsies.

Diverticulosis has no definite relation to the sex of the patient. Of 114 patients who had resections performed for

diverticulitis by coworkers and myself, 46.5% were males. In the younger age groups males predominated; in the older, females. Ages averaged from 29 to 87, the mean being 58 years.

PATHOLOGY.—Diverticula, consisting of herniations of mucosa and submucosa through the wall of the gut may be covered only by serosa or may present within the mesentery or beneath epiploic appendages. They vary considerably in size, ranging from a few millimeters to several centimeters in diameter. The neck of the sac is usually narrow, so that fecal matter readily becomes impacted within it. Diverticula of this type are termed "acquired," or "false."

When a true muscular coat is present in the wall of the diverticulum, such as in a Meckel's diverticulum, it is called a "congenital" or "true," diverticulum. In the colon the only congenital diverticula are encountered in the cecum, and even there acquired ones appear also.

The preponderance of diverticula in the sigmoid is overwhelming. Ninety per cent of definitive operations for diverticulitis performed at Massachusetts General Hospital have required sigmoid resection. The others are divided almost equally between the right, transverse and descending colon and intraperitoneal rectum, with 2-3% of the total appearing in each segment. In most patients diverticula are numerous in the sigmoid and are scattered, appearing less frequently from left to right throughout the proximal colon.

There has been a great deal of speculation concerning why sigmoid diverticula are much more likely to lead to trouble than are those in other portions of the colon. Several factors, perhaps, are important. The sigmoid flexure contains solid feces that fill diverticula, producing mucosal erosions and diverticulitis. Thin fecal matter found in the proximal colon is not so likely to produce this trauma. Once inflammation begins, edema tends to occlude the lumen of the bowel. For anatomic reasons, obstruction is most likely to occur at a flexure of the colon. Finally, the lumen of the sigmoid is often narrower than other portions of the colon, adding to the possibility of obstruction.

Following the same reasoning, it has been pointed out that the removal of one of these factors—the narrow sigmoid flexure—accounts for the successful clinical results following limited segmental resection for this disease. Thus, resection of the sigmoid flexure converts the left colon and rectum into a relatively straight tube, so that back pressure is not trans-

ferred to diverticula in the wall of the flexure, but rather back through the lumen of the colon.

The inflammatory change in the diverticula is due to the mixed flora of the colon and not to any specific organism. *E. coli* and *Streptococcus faecalis* predominate in abscesses that are secondary to this disease. When they invade the wall of the gut, a cellulitis or phlegmon of the colonic wall may occur, or an abscess form. The abscess may be relieved by spontaneous discharge into the lumen, persist adjacent to the colon until drainage is carried out or perforate into the free peritoneal cavity.

With continued episodes of inflammation, the wall of the colon becomes thick and edematous, the lumen narrow, the mesentery greatly thickened and the colon shortened. Inflammatory adhesions attach to adjacent viscera, particularly to the bladder in males and to the uterus, left tube and ovary in females. Perforation through the skin or vagina or into a neighboring viscus will lead to a fistula.

Although the question arises often, there is no evidence that the long-standing inflammation secondary to diverticulitis will lead to cancer.

COMPLICATIONS AND SEQUELAE.—Complications of diverticulitis include:

1. *Perforation.* This is of variable significance, depending on the site and amount of contamination. A perforation into the mesentery will produce a localized pericolic abscess, not manifested by signs of peritonitis but rather by localized tenderness over the sigmoid region, fever and possibly signs of obstruction. A mass is often palpable by abdominal or rectal examination.

A perforation lateral to the colon is likely to be walled off rapidly by inflammatory adhesions and to produce the usual signs of an intra-abdominal abscess. Fever and localized tenderness over a palpable mass are the usual signs.

If the perforation occurs on the anterior or medial walls of the colon, chances that it will be walled off spontaneously are much less, and a lower abdominal or general peritonitis will occur. Diffuse tenderness, rebound tenderness and spasm replace the local tenderness noted with an abscess.

If the colon previously had become adherent to a neighboring viscus or to the peritoneum, and if the perforation occurs at this site, further progression of the inflammation will lead to fistula formation. Sigmoidovesical fistulas are by far the most common. Less frequent are fistulas to the vagina, small

intestine or skin. Fistulas to the uterus or ureter are uncommon.

2. *Obstruction.* Where obstruction is due to diverticulitis, it is likely to be chronic, with episodes of more acute symptoms interspersed with periods of comparative freedom. This is due to the fact that in the early stages edema increases and decreases in relation to the inflammatory process present. Finally, however, if surgical relief has not been given, an acute obstruction will supervene. In a few cases the obstruction may be acute, without premonitory symptoms. This can occur with the sudden development of an abscess, but obstruction must always raise the question of cancer. In Massachusetts General Hospital, approximately 80% of acute obstructions of the colon are due to cancer, 15% to diverticulitis and 5% to other causes, of which volvulus is the most common. Occasionally a sigmoid diverticulitis may lead to inflammatory adhesions and acute obstruction of the small intestine.

3. *Hemorrhage.* The incidence of hemorrhage in diverticulitis is much discussed. The problem is complicated by the fact that pathologists, in specimens resected for hemorrhage, are almost never able to locate any microscopic evidence of the source of bleeding, such as an open vessel in a diverticulum. The somewhat indirect reasoning is that some patients with diverticula have bled before the segment of colon was resected, and not after its removal. It seems logical, therefore, to ascribe the bleeding to the diverticula even though, in some instances, it may have arisen from the hemorrhoidal area, irritated by the constipation or diarrhea occasioned by diverticulitis.

Consequently, when bleeding is noted in the presence of known diverticulitis, the physician should consider other causes of bleeding from the colon. The most important are cancer and adenomatous polyps. Others include ulcerative colitis, hemorrhoids and erosions over a hypertrophied ileocecal valve.

When these other lesions have been eliminated, it is found that bleeding is still a common symptom, as observed in 27% of patients who required a resection at Massachusetts General Hospital. As this figure is likely to include the most severe cases, since they were the ones operated on, it is interesting to note that LeRoyer and White found the incidence of bleeding 15% in 200 unselected cases.

Other series reported an even higher bleeding frequency. Noer's series of 68 patients with diverticulosis and diverticu-

litis showed gross rectal bleeding in 20 and, in reviewing 28 reported series, gross bleeding in approximately 11%, i.e., 324 of 2,896 patients. Willard and Bockus reported bleeding in 39% of their series of 72 cases.

That bleeding does occur and is frequent in patients with diverticulitis cannot be denied. The nature of the hemorrhage is often somewhat different from that found in other colonic lesions. This will be considered under Differential Diagnosis.

4. *Other, bizarre sequelae* may follow an extensive diverticulitis. For example, Hamlin observed a complete slough of the sigmoid following this disease.

Diagnosis

Diverticulosis is presumed to be asymptomatic. Theoretically, at least, this is true, since some inflammatory change is necessary, for example, to erode mucosa over a vessel and to produce hemorrhage. It must be admitted that in some instances pain, typical of diverticulitis, appears in a patient whose colon, by barium enema, shows no evidence of spasm, but merely diverticulosis. However, it seems more logical to assume that diverticulosis is asymptomatic, and that these symptoms indicate diverticulitis, even though diagnostic methods are not always exact enough to demonstrate it.

Symptoms.—Diverticulitis symptoms are variable, depending on the extent of disease and location of diverticula. Before discussing individual symptoms, the course of a typical case of diverticulitis will be described.

In a typical attack of diverticulitis, a middle-aged patient complains of a sudden onset of left lower abdominal pain. This is associated with mild constipation or, occasionally, diarrhea and anorexia. On examination, slight left lower quadrant tenderness is present. There is slight fever and leukocytosis. After a few days of rest and restricted diet, symptoms disappear and the patient feels normal again.

This mild, benign form of the disease is encountered in about three fourths of patients with diverticulitis admitted to the hospital for diagnosis and treatment. In other patients the onset is much more dramatic, due to the presence of one of the complications of the disease, or the symptoms persist in a more or less chronic state with remissions and exacerbations.

It would be fortunate if there were some way by which the prognosis of patients with mild symptoms could be determined. This point will be discussed in more detail later. Here

it will be emphasized that the life history of the disease is so variable that prognosis is most difficult and will depend, to a great extent, on an individual consideration of the symptoms and careful, continued observation of every patient.

Consequently, the individual symptoms must be considered carefully. They are, in approximate order of frequency, abdominal pain, fever, constipation, diarrhea, abdominal distention, dysuria, frequency, palpable mass discovered by the patient, nausea, vomiting, rectal bleeding, pneumaturia and a fecal fistula.

(a) *Abdominal pain* varies from mild to severe. Usually, in the absence of perforation, it starts suddenly, is moderately severe and then, after several hours, becomes dull and steady but remains localized in the left lower quadrant or suprapubic areas. Sudden, severe pain that continues without remission suggests a perforation; if it remains localized, an abscess is probable, but if it becomes more diffuse spreading peritonitis must be suspected. If the pain is colicky, intestinal obstruction must be considered. Cramps may be mild, relieved by the passage of a stool from the inflamed area, or severe, when associated with complete obstruction.

Pain may also be felt in less common sites. At times the pain of diverticulitis and the associated local tenderness may be noted in the right lower quadrant only. While this is not unexpected, when the diverticulitis involves the cecum, it must be recognized that this can occur with sigmoid diverticulitis as well; here it is due either to a perforation to the right of the midline, or to a long-inflamed sigmoid loop located in that site. Pain may also be localized in the perineum where diverticulitis involves the colon just above the peritoneal floor.

(b) *Fever* occurs with recurrent attacks of inflammation, and may be associated with chills. This is a major complaint in nearly half the cases. Actually, the percentage of patients who have fever is much higher.

(c) *Constipation* frequently accompanies diverticulitis, although it is impossible statistically to prove even a casual relation. At any rate, whenever an acute attack of diverticulitis occurs, constipation becomes more severe because of the accompanying ileus. Obstipation, of course, suggests organic obstruction.

Closely related to the symptom of constipation is that of tenesmus. This consists of a frequent desire to go to stool, with the production of only small amounts of fecal matter. This symptom often is described by patients as constipation.

However, it is essential to question closely, because actual tenesmus is rare with diverticulitis but common with cancer.

(d) *Diarrhea* is also common, and tends to occur just before or after an exacerbation of diverticulitis. Consequently, alternating constipation and diarrhea may be noted. Diarrhea in chronic stages of the disease may be extremely troublesome. It is associated with active inflammation or with stenotic changes in the colon that have produced partial obstruction.

(e) *Adbominal distention* is a common complaint, occurring either at intervals with exacerbations of the disease or with an acute obstruction. Even though actual diverticulitis cannot be demonstrated, the patient may still complain of flatulence, with relief when gas is passed through the anus.

(f) *An abdominal mass,* or localized tenderness, actually are details noted on the physical examination that sometimes are discovered by the patient.

(g) *Rectal bleeding* is observed by approximately 15-20% of patients with diverticulitis. As will be noted in the section, Differential Diagnosis (p. 19), details of bleeding episodes are extremely important.

(h) *Urinary symptoms* may be due to unrelated inflammation in the urinary tract, but must be regarded with suspicion. Particularly in males, or in females who have had a hysterectomy, these symptoms often precede the development of a sigmoidovesical fistula. Later, after it has formed, gas or feces appear through the urethra. Pneumaturia, in the absence of diabetes, is almost always due to a sigmoid fistula secondary to diverticulitis.

(i) *Nausea and vomiting* occur occasionally with acute attacks of diverticulitis, signifying either acute inflammation or obstruction. These symptoms are encountered in approximately 10-20% of patients with sigmoid diverticulitis, but rarely are prominent.

(j) *A fecal fistula* may be the primary complaint. It may develop either spontaneously or follow an operative procedure.

PHYSICAL EXAMINATION.—Physical signs of sigmoid diverticulitis usually are limited to findings in the abdominal, vaginal or rectal examinations. Abdominal tenderness, distention or a palpable mass are the most common.

Tenderness is located over the site of inflammation, usually in the left lower quadrant. However, it may start in the suprapubic area or right lower quadrant. Depending on the severity of the process, tenderness may vary from slight to marked.

When lower abdominal or general peritonitis develops, tenderness spreads and is associated with rebound tenderness.

Distention may be secondary to mild inflammatory change and reflex ileus or to actual obstruction. The severe degrees of distention associated with acute obstruction of the colon due to cancer are not often encountered with diverticulitis.

A mass may be expected in one third to one half the cases. It may represent an inflammatory process or, in part at least, be formed by retained feces just above the diverticulitis. Rather sudden resolution of a mass, therefore, is not uncommon and is much more likely to be due to release of a fecal impaction rather than to spontaneous rupture of an abscess into the lumen of the bowel.

In some instances a mass may not be palpable on abdominal examination but may be felt easily by rectal or vaginal examinations. Bimanual examination, with the patient in lithotomy position, is the best method to detect these masses. Although a mass due to diverticulitis usually subsides rapidly as inflammation is relieved, it may persist for days or even months, for an actual phlegmon with sinus tracts, multiple abscesses and scar tissue may form. Such a development is unusual, however, and a persistent palpable mass, therefore, always raises the question of cancer.

In addition to the left lower quadrant masses that occur with sigmoid diverticulitis, fecal retention in the right colon may lead to an easily palpable cecum.

Auscultation always should be carried out. Peristaltic sounds are diminished during the phase of acute inflammation and are absent with general peritonitis. They are increased with acute obstruction. Fever is present during the acute phases of an attack.

Sigmoidoscopy should be an integral part of the examination, and must be done with great care when inflammation is acute. In many cases, there is extreme danger of perforation, so that the instrument must be passed with great care, and inflation with air avoided. In chronic cases these hazards are not so important; a better preparation of the colon and more informative examination may be expected.

The greatest value of this procedure is to rule out the presence of other lesions such as cancer of the colon. However, not uncommonly, positive information confirming the presence of diverticulitis may be found. Suggestive changes are erythema or edema of the mucosa, fixed angulation of the rectum or narrowing of the lumen. The type of discharge at the

upper end of the scope should be observed; the feces often contain mucus. Blood, when seen, will be bright or cherry red. Not commonly, but at times, the orifice of the diverticulum can be visualized at a depth of 16 cm. or more.

Because of the difficulties of this procedure in acute phases, the examiner should be equipped with a suction device to keep the rectum empty as he proceeds.

ROENTGENOLOGIC DIAGNOSIS.—Confirmation of the clinical diagnosis of diverticulitis rests chiefly on the roentgenographic evidence. Diverticulosis usually is demonstrated easily in the colon well prepared by barium enema. A 24-hour film may show isolated diverticula filled with barium. In addition to diverticula, when diverticulitis is present, spasm can be demonstrated. In the acute phases the diverticula may be visible only as tiny, saw-toothed projections and, in rare instances, may not be visible at all.

The typical defect in diverticulitis of the sigmoid is an area of spasm several centimeters long in which the mucosal pattern can be identified. The ends of the defect are cone shaped.

In uncomplicated cases of diverticulitis, the most difficult differential diagnosis involves cancer of the colon. Schatzki has stressed that the diagnosis may be easy, but at times it may be impossible. He emphasizes the following diagnostic features:

1. In diverticulosis a long segment of the bowel is likely to be involved, while in carcinoma a short one is affected. This is not always true, since extensive cancer may produce a long defect.

2. In diverticulitis the mucosa is intact, but in carcinoma it is destroyed.

3. A bizarre, fringed contour (picket-fence deformity) is more often associated with diverticulitis.

4. Spasm of the colon is more constant in diverticulitis than in carcinoma.

5. The presence of diverticula in remaining areas of the colon suggests that the local area in question may be diverticulitis. However, the frequency with which cancer and diverticulitis coexist in the same segment of bowel makes this finding of relative value only.

6. The presence of tapered or cone-shaped ends of the bowel outlined above and below the involved segment suggests diverticulitis. In carcinoma the transition is usually more abrupt, and normal bowel outline is terminated with a blunt narrowing.

In the presence of complications in diverticulitis, special problems arise. If perforation has occurred, a barium enema is dangerous, since extravasation of barium may occur into the peritoneal cavity. Hence, if this is suspected, upright or lateral decubitus films should be taken first, since free air may be discovered in the peritoneal cavity. The barium enema, if given at all under these circumstances, must be administered with great caution and stopped if there is a trace of extravasation. Acute diverticulitis, without evidence of perforation, does not contraindicate a careful barium enema.

Obstruction can be diagnosed on the plain film. If there is obstruction to the retrograde flow of barium, it will be impossible to delineate the lesion by barium enema.

Fistula formation can sometimes be demonstrated by barium enema. A sigmoidovesical fistula, however, rarely can be shown in this way, since the opening may be extremely small. A cystogram is more likely to demonstrate it.

Among the other radiologic examinations, the intravenous pyelogram is the most important. Although the left ureter is often closely involved in the inflammatory process, actual obstruction with hydroureter and hydronephrosis is uncommon. Partial or complete block of one or both ureters strongly suggests cancer.

OTHER STUDIES.—Other studies are often important in making the diagnosis. The stool should be examined for gross or occult blood. Papanicolaou smears of rectal washings are sometimes helpful in distinguishing diverticulitis from cancer. A satisfactory specimen may be obtained after a defunctioning colostomy, but is difficult to get if the fecal stream has not been interrupted.

Blood counts, smear, differential count and sedimentation rate may aid in confirming the presence of an inflammatory process. A cystoscopy is the best method for obtaining information when a fistula into the bladder is suspected. A localized area of inflammation is found at the dome or posterior surface of the bladder. Occasionally the fistula may be seen, discharging feces.

In the presence of a rectal stricture, a Frei test may be advisable to rule out lymphogranuloma inguinale.

DIFFERENTIAL DIAGNOSIS.—Differential diagnosis of diverticulitis includes many other diseases that are important, depending on the presence or absence of specific complications of the diverticulitis. The most common are:

(a) Acute diverticulitis—acute appendicitis, pelvic pathol-

ogy in females, such as endometriosis or a twisted ovarian cyst, perforated cancer of the colon, left ureteral colic.

(b) Diverticulitis with perforation—perforated appendix, perforated cancer of the colon.

(c) Diverticulitis with bleeding—cancer of the colon, adenomatous polyps of the colon, ulcerative colitis, hemorrhoids.

(d) Diverticulitis with obstruction—cancer of the colon.

It is obvious that the disease confused most frequently with diverticulitis is cancer of the colon. This important differential diagnosis will be considered in the next section.

Acute appendicitis is likely to be diagnosed when diverticulitis is in the cecum, since the symptoms of diverticulitis in this segment are markedly similar to those of a retrocecal appendicitis. In such cases the typical pain shift of other types of appendicitis is less likely to occur, nausea and vomiting are not common and diarrhea may be noted.

It has been stated already that sigmoid diverticulitis may demonstrate the same physical signs and have a similar history to that of appendicitis. However, the absence of a pain shift from the epigastrium to the right lower quadrant, the relative rarity of nausea and vomiting and the tendency for pain and tenderness to be located in the left lower quadrant or suprapubic areas suggest diverticulitis. A history of a previous appendectomy furnishes the best differential feature.

The possibility of left-sided appendicitis associated with situs inversus must not be forgotten. Since in most cases this is not complete, dextrocardia will alert the examiner, who may have the diagnosis confirmed by barium enema.

Pelvic pathology in females may resemble diverticulitis. Acute episodes in diverticulitis may be similar to those encountered with a twisted ovarian cyst, salpingitis, ruptured endometrial cyst or infarcted fibroid. During chronic phases any pelvic tumor that lies in the left vault may form a mass indistinguishable, on physical examination, from that due to diverticulitis.

A difficult diagnostic problem may arise when a female patient has diverticulitis and a pelvic mass. If the mass represents a malignant tumor rather than the inflammation secondary to diverticulitis, the chance of cure may be lost by procrastination. The danger of delay is increased if the patient has any symptoms referable to the genital tract.

Left ureteral colic may resemble pain arising from diverticulitis. Pain from diverticulitis rarely is reflected into the thigh or into the costovertebral angle. Ureteral pain is ex-

tremely severe and almost always colicky; that of diverticulitis tends to be steady and if colicky is located below the umbilicus.

Acute gastroenteritis may resemble an attack of diverticulitis. The rapid course of the disease, colic in the absence of distention and shifting areas of tenderness are typical of enteritis rather than of diverticulitis. Tenderness is minimal or absent with the bacterial dysenteries.

Ulcerative colitis may, like diverticulitis, produce rectal bleeding and diarrhea. In most instances there is no difficulty in the differential diagnosis, since ulcerative colitis tends to appear in young adults, and typical changes can be demonstrated on sigmoidoscopy. In some older patients the diseases may coexist. A segmental colitis involving the left colon makes the interpretation difficult.

Rectal bleeding is such a common symptom that more attention must be given to it. Profuse hemorrhage in a patient over 50 is likely to be due to diverticulitis whereas in the young adult ulcerative colitis is the usual cause. Intermittent attacks in which small amounts of bright or cherry-red blood are found mixed with feces also are other signs typical of diverticulitis. When small amounts of blood are present daily, with no change in bowel habit, a polyp usually causes the bleeding. If there are frequent discharges of blood or blood mixed with feces, ulcerative colitis is more common in the young and cancer in the old.

Other rarer diseases that occasionally must be considered in the differential diagnosis of acute diverticulitis are torsion of an epiploic appendage, strangulated hernia (Richter's or intra-abdominal) and mesenteric thrombosis. Urethral obstruction leading to urinary retention may produce lower abdominal cramps. Tuberculosis, lymphogranuloma inguinale and actinomycosis may simulate diverticulitis in chronic phases of the disease. Retroperitoneal tumors, lymphomas and perinephric abscesses may be confused.

Diverticulitis and Cancer of Colon

There are three special points of interest relating diverticulitis to cancer of the colon. They are: (1) the question of any causal relation, (2) the difficulty of differential diagnosis and (3) the clinical aspects when these diseases exist simultaneously. These will be discussed in order.

1. Significance of diverticulitis as a premalignant lesion.

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1. Significance of diverticulitis as a premalignant lesion.

Chronic inflammation in various parts of the body finally may lead to malignant degeneration. Thus, old burns, osteomyelitic sinuses or long-standing fistulae in ano eventually may result in epidermoid carcinoma. It has been suggested that, by analogy, diverticulitis may be a precursor of cancer. There is no evidence to prove this supposition. The simultaneous occurrence of the two lesions is uncommon and not more frequent than would be expected in older patients in whom both diseases are common.

Moreover, diverticulitis usually does not exist as continued acute inflammation but occurs as short episodes of inflammation with long intervals in which the colon is normal except for the inflamed diverticula; the situation, therefore, is not analogous to the conditions just described.

Whereas cancer and diverticulitis may coexist in the same segment of colon, these lesions are almost always separate and distinct. When they are adjacent, a more attractive theory of pathogenesis of the cancer is that it arises from an adenomatous polyp that occasionally develops in the same segment as the diverticulitis.

2. Differential diagnosis of diverticulitis and cancer. Often this is easy, but it may be impossible by any means other than examination of the resected specimen. Diverticulitis may mimic cancer closely. The frequency with which this similarity occurs can be estimated only in general terms, although in a series of resections performed several years ago at Massachusetts General Hospital the preoperative diagnosis of cancer made in 18% of specimens examined was proved by the pathologist to be diverticulitis. This is not a serious error, because almost all patients had an obstruction or perforation for which resection was indicated, regardless of the cause.

On the other hand, when cancer mimics diverticulitis, the situation is much more serious, in that conservative therapy may allow metastasis before the indicated resection is performed. Although this diagnostic disaster now should be rare, it can be eliminated only by more rapid recourse to surgery in all questionable cases. Any of several points should raise a warning.

Symptoms of cancer tend to be steadily progressive, those of diverticulitis, intermittent. Tenesmus is frequent with cancer of the rectum, rare with diverticulitis. The nature of rectal bleeding is important, because that from cancer usually is small in amount, but is repeated with every bowel movement.

That from diverticulitis tends to be intermittent and, not uncommonly, massive.

Patients with diverticulitis usually improve rapidly on conservative therapy. If they fail to do so surgery is indicated, not alone to relieve symptoms but to treat appropriately patients who have cancer who, characteristically, respond to conservative therapy slowly and temporarily. Thus, a patient with a palpable mass should have surgery unless there is rapid resolution within a short observation period.

In many instances, the radiologist may find it difficult to make the differential diagnosis of diverticulitis and cancer. This has been considered previously. Here it will be emphasized that surgery is indicated when the roentgenologic diagnosis is equivocal.

Roentgenologic diagnosis is impossible with obstruction of the colon where no delineation of the colonic lesion by barium can be obtained. In some cases there may be no obstruction to the flow of feces from above, but there is obstruction to the retrograde flow of barium. In all such cases surgery is indicated.

A transverse colostomy is performed in many instances in which the diagnosis of a sigmoid lesion is equivocal. If the lesion is diverticulitis, there almost always is prompt improvement, although in 5-10% of cases the phlegmon of the bowel wall is so extensive that mass and fever persist. However, after a colostomy, persistent rectal bleeding and a mass, particularly in the absence of any significant fever, are almost certain evidence of cancer. The contemplated resection in these cases should be performed a week or two after the colostomy rather than be deferred for the longer period that would be desirable if the lesion were diverticulitis. After a transverse colostomy, rectal washings can be obtained; if they are positive or suggestive of cancer, early resection is indicated.

3. Coexisting diverticulitis and carcinoma. This combination is uncommon. Rauch has collected and analyzed the reports of 15 surgeons who provided 118 cases. The average age of patients was 64, with 57% males. Both lesions occurred in the same segment of the colon in 73%. Data showed the cancer to be distal to the diverticulitis in 17%, and proximal in 10% of patients. Although, theoretically, it should be expected that cancer might influence the development of inflammation in proximal diverticula, there was insufficient evidence for proof.

The rate of cure is distinctly lower than that for the usual

cancer of the colon. In the group studied only 24% of the total number of patients were alive and free from disease at the end of 5 years, and only 35% of those with potentially curable lesions were living and well at the end of this period. A most important factor in these cases was the delay before treatment, for by far the lowest incidence of metastasis and highest 5-year survival rate occurred in patients receiving surgical treatment within 3 months of the onset of symptoms. Thirty-six of 110 patients had had a preoperative diagnosis of diverticulitis, subsequent temporization and delay, with a 5-year cure rate of 17%. Of the 74 patients who had the correct diagnosis of cancer, 30% were well 5 years later.

In conclusion, it may be said that cancer masquerading as diverticulitis is an ever-present threat. An aggressive surgical attack on all questionable lesions is the only method for reducing deaths from this cause.

Therapy in Sigmoid Diverticulitis

Medical treatment.—To initiate medical treatment, the physician must be assured that the patient has no evidence of free perforation of a diverticulum or of significant obstruction or major bleeding. Essentials in medical treatment of diverticulitis consist of bed rest, diet, antispasmodic and lubrication or softening of the fecal stream. In many instances, antibiotics should be added.

Diet in diverticulosis or mild diverticulitis should be of the low-roughage type. Raw fruits and vegetables, nuts and food with coarse vegetable fibers are omitted. The low-roughage diet outlined by the dietary department of Massachusetts General Hospital is as follows:

Foods Allowed

Milk: 1 pint maximum. *Eggs:* in any form except fried. *Meat:* beef, veal, lamb, liver, crisp bacon, fowl, fish. *Cheese:* cottage, cream, mild cheddar. *Cereals:* refined, enriched, rice, macaroni, noodles, spaghetti. *Bread:* white, enriched, soda crackers, rusk, zwieback. *Vegetables:* cooked and puréed: potatoes well baked or mashed, tomato juice (usually no more than 2 servings besides potato), well-cooked carrots, beets, squash without seeds. Asparagus tips may be added, if ordered by the physician. *Fruits:* canned peaches, pears, cherries, apricots (without skin), applesauce, baked apple (without skin)

(fruits are cooked and puréed), strained fruit juices, lemonade—usually no more than 3 servings. *Dessert:* custard, plain ice cream, junket, puddings (limited by milk allowance), plain flavored gelatine, plain cake or cookies. *Soups:* strained vegetable soups, broth, bouillon. *Beverages:* coffee, tea, carbonated beverages (unless ordered omitted). *Butter, cream,* in moderate amounts; *sugar, jelly, honey,* in moderate amounts.

Foods Avoided

Cabbage, onions, turnips, cauliflower, radishes; all fried foods; highly seasoned foods, spices, vinegar; coarse wholegrain cereals, and bread; hot breads, pastry, rich cakes or cookies; jams or preserves containing skins or seeds of fruit; nuts and dried fruits, such as raisins, dates, figs; raw fruits and vegetables; chilled foods, frozen desserts.

Suggested Meal Plan

BREAKFAST: strained fruit juice; cereal, cream, sugar; egg; white toast, butter; milk (4 oz.); coffee, cream, sugar.

DINNER: meat, fish, fowl; potato; vegetable; dessert (without milk); milk (6 oz.); tea, sugar.

SUPPER: strained soup (optional); meat or substitute; potato or substitute; white bread, butter; milk (6 oz.); tea, sugar.

When diverticulitis is acute, food intake must be restricted sharply. Intravenous fluids will be necessary if there is any peritoneal irritation. As the patient improves, the oral intake is limited to warm liquids; later solids are added. After recovery, if the patient is obese, a weight-reduction program should be carried out.

Antispasmodics are valuable during the acute exacerbation and if diarrhea and cramps are troublesome chronic symptoms tincture of belladona is given in as large doses as can be tolerated. Beginning with 10 drops, 3 times a day, 15 minutes before meals, the dose is increased by a drop each day until toxic symptoms, such as eye signs or flushing appear. It is then reduced to the last tolerated dose and maintained at that level. Numerous other antispasmodics are available, one of which may be tolerated best by the individual patient. Their therapeutic value consists of decreasing peristalsis and thereby encouraging reparative processes in the inflamed colon.

The colon may be lubricated by mineral oil. Doses of 1 tea-

spoonful twice daily usually are sufficient. Larger doses tend to run through the anal sphincter. Since oil diminishes the absorption of vitamins, it is better to use other substances for continued therapy. Metamucil® increases the bulk of the stool and makes it softer. The dosage is 1 teaspoonful once or twice daily, with adequate fluid.

A new wetting agent—Dioctyl Sodium Sulfosuccinate—recently developed, has proved effective in softening feces. It also increases the bulk of the stool moderately. Although its value in treating chronic symptoms of diverticulitis has not yet been assessed, theoretically it should be of value.

Antibiotics and chemotherapy are important in treating acute diverticulitis. Sulfathalidine® or Sulfasuxidine® will soften the feces and lower bacterial content. Orally, Sulfathaladine®, 2 Gm. 4 times daily, is preferred. Neomycin may be given orally 8 Gm. daily for 3 days. Parenteral antibiotics, including a combination of penicillin and streptomycin, or Chloromycetin®, tetracycline or oxytetracycline may be given when oral intake is impossible.

Bacteria are reduced most effectively by the more powerful and, especially, by the broad-spectrum antibiotics. Clinical experience has shown a high incidence of yeast diarrhea after their continued use. Also, the serious and sometimes fatal disease of staphylococcus enterocolitis has followed their use, resulting from overgrowth of a staphylococcus in the bowel that has been rendered essentially free from *E. coli*. Broad-spectrum antibiotics are given for only a few days and only for acute diverticulitis. In the acute stages rest in bed is important, and, since the ultimate course of any single episode is unpredictable, it is wise to hospitalize the patient for close observation. If sedatives are necessary to control discomfort, the barbiturates and Demerol® are preferred. Codeine is avoided because of its constipating effect. Local heat, using a heating pad or hot abdominal pads, often is comforting to the patient. Transfusions may be necessary to correct blood loss.

After an acute episode has subsided, the patient must continue with a low-roughage diet and Metamucil®. If colonic spasm, flatulence or diarrhea continue as troublesome symptoms, tincture of belladonna is given, as indicated previously, and phenobarbital (30 mg. 3 times a day) is added.

Laxatives and enemas are contraindicated during the acute phase of diverticulitis and should be used with caution at other times. Diverticula are easily perforated by enemas. Mild

laxatives, such as milk of magnesia, may be necessary for relief from constipation when the diverticulitis is quiescent.

SURGICAL TREATMENT.—Indications for surgery have broadened in recent years for many reasons, the most important of which is that postoperative mortality has decreased, despite the fact that more extensive operations are feasible and cure can be effected by resection of the involved segment of colon. Furthermore, earlier resections have led to more frequent use of a one-stage resection and anastomosis rather than to the time-consuming staged operations requiring the patient to have a colostomy for several months.

Surgery may be indicated in the following categories:

1. The patient manifests one of the complications of diverticulitis: (*a*) perforation either with a pericolic abscess, or where local or general peritonitis is present; (*b*) colonic obstruction is present. This may be demonstrated by complete obstruction, but more commonly by a more chronic type with continued colonic cramps and mild distention; (*c*) hemorrhage, continuing and massive, uncontrolled after transfusions, is a positive indication for surgery. However, postoperative complications are so common after an emergency operation for acute massive hemorrhage that this operation should be avoided if possible. After conservative therapy and recovery from a single major hemorrhage, the patient is placed on a good medical regimen; if there is a second hemorrhage, an interval resection is advised. Relatively minor bleeding may also be an indication for surgery, if it is repetitive and occurs daily, since a cancer or adenomatous polyp of the colon may be present also; (*d*) fistula formation indicates surgery, because it is rare that a fistula can be closed any other way. Spontaneous closure of a sigmoidovaginal or a sigmoidocutaneous fistula can occur, but usually fibrotic changes and partial obstruction in the colon keep it open. A sigmoidovesical fistula is an extremely serious complication, because it leads to widespread infection of the urinary tract, and thus surgery should not be delayed.

2. The disease probably is diverticulitis, but certain features strongly suggest cancer. This differential diagnosis already has been considered, but it is well to re-emphasize the significance of rectal bleeding, the symptom of tenesmus, the presence of a palpable mass or an equivocal radiologic examination.

3. The patient has had one or more previous attacks of diverticulitis and presents one of these problems: (*a*) the acute

attack has subsided but symptoms of cramps, bloating, diarrhea or constipation have persisted despite good medical care; (*b*) two separate attacks of diverticulitis have occurred, requiring hospitalization because of pain or hemorrhage. Even though the patient now is asymptomatic, surgery is warranted in the absence of any contraindication; (c) diverticulitis appearing in patients under 50 is an indication for resection; (*d*) the onset of urinary symptoms in a patient with known diverticulitis is likely to signify a fistula into the bladder, an indication for early surgery; (*e*) severe deformity of the sigmoid, demonstrated by radiologic examination, persists after conservative therapy. These changes indicate fibrosis and furnish a definite prognosis of serious complications unless a resection is done.

It should be emphasized that all indications must be interpreted with due regard for the multiple problems presented by every patient. Diverticulitis is essentially a benign disease; operation need not be mandatory in many instances because of such factors as age or obesity. Moreover, in all instances except those in which emergency operations are necessary, it is possible to put patients in the best physical condition before surgery. Several months of vigorous diet may accomplish much as a preoperative measure.

4. Operations for diverticulitis include exploratory laparotomy, with or without drainage, cecostomy, colostomy and resection of the involved segment. Local excision of a single diverticulum never is possible except where there is a solitary diverticulum of the cecum. These operations will be discussed briefly.

(a) *Exploratory laparotomy.* Sometimes laparotomy is required to establish the diagnosis of diverticulitis. This is true particularly in the acute inflammatory processes that simulate other intra-abdominal pathology such as appendicitis. It is also necessary in some cases of intestinal obstruction or of bleeding from an indeterminate source.

Usually the surgeon's course is clear as soon as the diagnosis is made. Thus, a perforation should be closed or the involved segment removed by an immediate resection. Abscesses should be drained, placing the drains preferably lateral to the colon. Obstruction must be treated by one or another type of proximal decompression or resection, and massive bleeding, by resection.

There remains, however, a group of cases in which diverticulitis of the sigmoid is relatively mild, with no obvious per-

foration or evidence of obstruction. In such cases the surgeon often wonders whether any definitive operation should be performed. Certainly many of these patients will do well if the abdomen is closed. It is my belief, however, that if the disease is severe enough to warrant an exploratory laparotomy it is serious enough to warrant resection of the involved segment. Inasmuch as the colon is rarely prepared well enough for an immediate resection, a transverse colostomy should be done as the first stage of a 3-stage resection.

(b) *Cecostomy.* Cecostomies are of two types. In the usual operation a large tube is sutured into the cecum; in the other the anterior wall of the cecum is opened and sutured to the skin. Both provide decompression of the colon but neither defunctions it entirely. Furthermore, they are temporary expedients which have little place in the treatment of diverticulitis, where it is often necessary to defunction the colon for long periods. This operation, therefore, is inferior to a transverse colostomy in the treatment of diverticulitis. It is used, however, for one important reason: if edema produces a temporary postoperative obstruction of an anastomosis, a cecostomy will tide the patient over the dangerous period, and it may be expected to close spontaneously thereafter.

(c) *Colostomy.* Colostomy is used to effect complete defunctioning of the distal colon. It may be used as the first stage of a 3-stage resection; it may be made concomitantly with the resection and anastomosis or it may be done several days after the resection, if the patient has complications referable to the anastomosis. Most commonly it is done for the first of these reasons.

The technical details of a colostomy will be discussed here with the 3-stage resections.

(d) *Resection of colon.* Resection of the colon may, at the option of the surgeon, be done in any of several ways described for convenience, as one-, two- or three-stage resections, according to the number of separate operative procedures required. In this section, technical details and indications for all 3 types will be described.

One-stage operations: In these operations, resection and primary anastomosis are carried out in a single procedure. This is the surgical method of choice but, because of the attendant technical difficulties, discretion must be used in selecting patients for this operation. Surgeons do not agree as to the extent of its applicability. Boyden believes that nearly all cases may be handled by this method. Waugh, in a recent report

from the Mayo Clinic, noted that 29% of the 320 operations for this disease between 1945 and 1954 were performed in this manner. At Massachusetts General Hospital, one-stage resections were used in 46% of these patients during the past 15 years. There appears to be less of a safety factor in these operations than in those that include a protecting colostomy. Particularly in a teaching institution, the requirements for this operation should be rather rigid.

Patients should be in good general health. It should be possible to prepare the colon by mechanical means and antibiotics. Patients with small abscesses that can be excised with the colon may have this operation. In the presence of general peritonitis or large local abscesses, however, it is dangerous. High-grade obstruction is also a contraindication. In the presence of a fistula, there is a chance of refistulization from the site of anastomosis, unless the colon has been defunctioned by a colostomy. In such cases a three-stage operation is safest.

Preferably, the colon is prepared by daily enemas and by antibiotics. Sulfathalidine®, 8 Gm. daily, is given for 5 days, or neomycin, 8 Gm. daily for 24 hours. Other broad-spectrum antibiotics, such as tetracycline, are not used because postoperative staphylococcus enterocolitis has been a serious complication in a few instances. Preoperatively, a Levin tube is inserted and a Foley catheter placed in the bladder.

A combination of Pentothal® with muscle relaxants is preferred for anesthesia. Good relaxation is essential if the splenic flexure must be mobilized. In the usual case this must be considered, so that a generous left paramedian incision is necessary. When the segment to be excised is short and in the midsigmoid, an oblique left lower quadrant incision is adequate.

After opening the peritoneal cavity, the surgeon determines the extent of the disease and mobilizes the colon sufficiently to obtain normal, flexible bowel at either end of the segment. Although the length of colon to be excised varies, an average length of 20 cm. is preferable, we believe, to the shorter segments often advised. In many instances, this will mean mobilization of the splenic flexure. Distally, the line of resection usually is about 5 cm. above the pelvic floor. It is practically never necessary to free the extraperitoneal rectum.

After mobilization has been completed, the colon is divided between Allen clamps at the upper end. A relatively small portion of the mesentery is excised and, if possible, the superior hemorrhoidal muscles are not divided. Distally, a clamp usually cannot be applied in the pelvis. The specimen is removed,

opened and examined by the pathologist. In an unexpected cancer is found, it must be known at this time and a wider resection done.

Then an open 2-layer anastomosis is made. The outer row is of interrupted cotton or silk and the inner, of interrupted catgut. Finally, the rent in the mesentery is closed. The left gutter is not reperitonealized.

The anastomosis is likely to be much more difficult than that after a similar operation for cancer, because the wall of the proximal colon is often relatively thick and the lumen narrow. Anastomotic complications, therefore, will occur unless great care is taken; they will be discussed in a later paragraph.

Two-stage operations: There are several two-stage resections that may be performed. They include:

1. Primary resection and anastomosis with concomitant proximal colostomy or cecostomy. In certain instances, the surgeon may plan a primary resection and anastomosis, be dissatisfied with the technical details and decide that some protection is necessary. If the lumen is narrow, and stomal obstruction from edema is likely, a cecostomy by the modified Gibson tube technic is satisfactory. Since most cecostomies of this type close spontaneously, this actually often turns out to be a one-stage operation.

When the anastomosis requires even better protection, a concomitant loop transverse colostomy is made. The colostomy can be closed 2-3 weeks later or as soon as the integrity of the anastomosis has been assured.

2. Primary colostomy, followed secondarily by resection of both the diverticula-bearing segment of the colon and the colostomy, with anastomosis. In this operation the colostomy is made in the descending colon or sigmoid just above the area of diverticulitis. This secures the benefits of a colostomy, allowing subsidence of the inflammatory reaction. At a later date the operation is completed by simultaneously excising a long segment of colon containing both the colostomy and the area of diverticulitis.

The operation has manifest advantages: It obtains the benefit of a proximal colostomy, yet avoids the third stage necessary in the three-stage operations. It also, at the time of resection, allows complete mobility of the colon. However, there are disadvantages that carry even more weight. The resection always has to be done through a contaminated field, since the colostomy must be mobilized during the course of

the abdominal incision; this increases the chances of sepsis. Also, in the ordinary three-stage operation, the anastomosis is protected by the colostomy and, indeed, this protection is one of the most important functions of the colostomy. Finally, if the supposed area of diverticulitis eventually turns out to be cancer, the manipulation of the colon near the lesion may be expected to abet metastasis or implantation in the abdominal wall.

3. Exteriorization of the involved segment of colon, followed by closure of colostomy. Exteriorization procedures, popularized by Mikulicz, Block and Paul, were used widely for several decades for treating cancer of the colon. The same principle was utilized by Rankin in his obstructive resection. Recently, however, the method has become much less popular and now rarely is used.

With diverticulitis, its chief value has been in the excision of an area within the site of an acute perforation. This method, theoretically, immediately exteriorizes the perforation and excises the area of diverticulitis. The resulting double-barrel colostomy can be closed later at an optimum date.

Unfortunately, this method is not always simple. The colon involved by diverticulitis usually is shortened, so that elevation of the entire area outside the abdominal wall may be impossible. At any rate, extensive manipulations in the presence of peritonitis are to be avoided, if possible. Consequently, if this operation is performed, it is likely to be unsatisfactory and incomplete. It is valuable as an expedient lifesaving measure in the presence of a large perforation, but not as a satisfactory way to dispose of diverticulitis.

Three-stage operation: The three-stage operation is safest to use, particularly in the presence of severe complications. However, it has the disadvantage of several operations and, because of protracted disability and long hospitalization, imposes a severe economic burden on the patient as well as the anxiety that accompanies a colostomy.

It consists of a preliminary colostomy in the transverse colon followed 1-12 weeks later by resection of the colon, and 1-4 weeks thereafter by closure of the colostomy.

The colostomy is made in the transverse colon far enough proximal to the lesion to allow adequate mobilization of the diseased segment. If the inflammation is restricted sharply to the sigmoid, the stoma can be placed in the left upper quadrant. If it is proved that the splenic flexure will need mobilization, the stoma should be placed in the right upper quadrant.

It must be recognized that in this location the stoma is less simple to control and that it is possible for an attack of acute cholecystitis to create an awkward situation. However, it is so essential to have a mobile colon for the anastomosis that these are secondary considerations.

The most elementary type of colostomy is the simple loop by which a short segment of the colon is withdrawn onto the abdominal wall and kept in place by a glass rod passed through the mesentery just below the bowel. It is opened 24 hours later by a short incision that divides only the anterior wall of the bowel. This method has the disadvantage that fecal spillover may occur from the proximal into the distal loop. This can be stopped, if necessary, by complete division of the loop at a later date.

A completely defunctioning colostomy is accomplished by dividing the colon totally and placing the stomas in either end of the incision with a skin bridge between. Even though this is a most satisfactory procedure, closure is somewhat more difficult than with the loop colostomy.

The second stage, consisting of resection and anastomosis of the involved segment of colon, is carried out by the method just described. The interval between the first and second stages is variable. The patient should have recovered completely from the first procedure. If there is a possibility that cancer is present, the interval should be 1-2 weeks. If, on the other hand, the diagnosis definitely is diverticulitis and there is a severe accompanying inflammatory reaction, every opportunity should be given for it to subside. Little is gained by waiting 3 months or more, for in most instances the resection is possible well before this time.

The final stage involves closure of the colostomy. This is a plastic closure of the stoma if the wall of the colon has not been divided totally, or an end-to-end anastomosis if the division has been complete. With either method, the sutured colon is returned to the peritoneal cavity. The abdominal wall is closed, either by primary or delayed primary closure.

The time for closing the stoma will depend on several considerations. If the postoperative course has been smooth, with nothing to suggest any malformation of the stoma, saline irrigations of the distal segment are begun a week after the resection. They confirm patency of the anastomosis. The stoma then is closed 10-12 days after the resection. On the other hand, if the postoperative course has been complicated, clo-

sure is not done until a month after operation. A longer interval than this may lead to anastomotic stricture.

If there is any question about the patency of the anastomosis, a careful barium enema should be given. Early after operation the barium often shows minute extravasations at the line of anastomosis. This is of no consequence and need not delay colostomy closure. Although some surgeons precede any colostomy closure by this study, it actually contributes little and generally is not necessary.

COMPLICATIONS AND MORTALITY.—Resection of the sigmoid for diverticulitis has been performed at Massachusetts General Hospital in 218 cases in a 15-year period, with a total mortality of 2.7%. Of these, 100 cases have been treated with a one-stage resection and anastomosis, with 3 deaths. Waugh reported 1 death in 93 one-stage resections, 2 deaths in 48 two-stage resections, and no deaths in 97 three-stage resections. Colcock reported 30 resections, 23 in one-stage, with no deaths. Bacon reported 73 resections, with 3 deaths.

Although death or postoperative complications may be due to many causes, by far the most important follow difficulties with the anastomosis. It has been emphasized previously that the colon involved by diverticulitis is difficult to handle, so that extreme care must be taken to avoid catastrophes. An anastomotic leak, if small, will lead to a pelvic abscess or to a recurrent sigmoidovesical or sigmoidovaginal fistula. If there is dehiscence of the entire anastomosis, general peritonitis and death follow.

If the anastomosis is narrow, edema may lead to intestinal obstruction: cecostomy will provide the essential temporary vent. On the other hand, a stenosis may not be manifested until months or years after resection, when progressive contraction of scar tissue has led to obstruction.

DIVERTICULA IN OTHER SEGMENTS OF THE COLON

Diverticula are found frequently in segments of the colon other than the sigmoid, being scattered from the ileocecal valve to just above the peritoneal reflexion in the pouch of Douglas. We have not encountered any beneath the peritoneal floor in the extraperitoneal rectum.

An interesting feature of diverticula occurring proximal to the sigmoid is that they produce symptoms infrequently, and if diverticulitis develops it tends to subside rapidly without necessitating operation. As the manifestations of the disease

vary somewhat, depending on the segment involved, each will be discussed.

DIVERTICULA OF CECUM AND ASCENDING COLON.—Diverticulitis of the right colon forms an important group, because patients with this disease usually enter with a diagnosis of appendicitis and, therefore, are subjected to operation. It might be anticipated that, if treated expectantly, many of these inflammatory lesions would subside spontaneously, but such a course would be unwise, if appendicitis is suspected.

An idea of the frequency of the disease may be gained from the fact that in our hospital, as Hermann found, 17 operations were performed for diverticulitis of the right colon during the same period that the 218 resections, discussed previously, were performed for sigmoid diverticulitis. Because of the comparative rarity of the disease, many cases of right-colon diverticulitis continue to be reported in the literature. In 1952, Lauridsen and Ross collected from medical reports 149 surgically proved cases of diverticulitis of the cecum and added 4 others. In 1957, Greaney and Snyder added 94 new cases.

According to Lauridsen and Ross, the median age of patients was 39, significantly lower than that for sigmoid diverticulitis. Cases included 84 men and 64 women. Symptoms closely resembled those of appendicitis. The most significant difference was that nausea occurred in only 27% of cases of acutely inflamed cecal diverticulitis, and vomiting in only 16%. According to the report, these symptoms are present in about 75% of patients with appendicitis. As pain and local right lower quadrant tenderness occur, the preoperative diagnosis has usually been appendicitis, except where the appendix had been removed previously.

A consideration of the etiology of diverticula in this section is fundamental to a discussion of appropriate therapy. It is probable that those occurring in the cecum are a different type from those found in the ascending colon. The latter resemble sigmoid diverticula, whereas cecal diverticula usually are solitary, occur in younger people and, on microscopic examination, demonstrate muscular layers.

These features indicate that the solitary cecal diverticulum has a congenital origin. Investigations by Kelly and Hurdon, confirmed by Gladstone and Wakeley, indicate that an outgrowth from the tip of the cecum occurs in the embryologic development of the gut, that this outgrowth enlarges during the sixth week and atrophies toward the end of the seventh week or soon thereafter. Gladstone and Wakeley call this a

"transient appendix" that simulates the true appendix in position. But because it later atrophies and disappears, it is probably an independent structure not connected directly with the permanent appendix, which is differentiated later. It is believed that this structure may persist in a few embryos and form the solitary cecal diverticulum.

DIAGNOSIS.—Symptoms and signs of diverticulitis of the cecum include local pain, tenderness, spasm and, occasionally, nausea and vomiting, or a palpable mass. It must be differentiated from appendicitis, cancer, ulcerative colitis and regional enterocolitis. Other cecal lesions, such as tuberculosis, amebiasis and actinomycosis may also be confused, but those situations are rare. As the preoperative diagnosis is usually appendicitis, often the surgeon is required to make the differential diagnosis after the abdomen has been opened and an unexpected lesion found.

TREATMENT.—If a definite preoperative diagnosis can be made of nonperforating diverticulitis of the cecum or ascending colon, it is appropriate to treat it conservatively. However, if the surgeon has opened the abdomen in the belief that the patient has appendicitis and has found an indefinite lesion that is either inflammatory or neoplastic, he is likely to be in a quandary. In some instances, the involved diverticulum is small and can be excised and the defect closed easily. In other instances, it is large, and the differentiation of cancer impossible without a pathologic section. It is my belief that if the diagnosis of diverticulitis is not reasonably clear, an immediate right colectomy should be carried out. Much damage may be done from attempting biopsies of the lesion if the bowel is opened. Cancer of the cecum is so common compared with diverticulitis that if the surgeon attempts to be absolutely certain of the diagnosis before resection, he is likely to jeopardize the cure of some cancers. This viewpoint is supported by the studies of Greaney and Snyder who found that in about a third of cases of acute cecal diverticulitis a mass is present that is indistinguishable from cancer until the resected specimen is examined.

It is interesting that Lauridsen and Ross found that the average cecal diverticulum had an average diameter of 2.7 cm., and an average ostium of 0.9 cm. More than half the diverticula contained a fecalith. They prefer local resection, as the mortality after local excision was 1.6% compared with 7.3% for resection. However, it should be expected that resec-

tion would carry a higher mortality than would simple excision, as resection is necessary for the largest lesions.

These figures do show that immediate resection carries a definite hazard and that the surgeon should attempt to make the correct diagnosis and to treat all single cecal diverticula that can be excised with closure of the defect by a simpler technic. Identification of a diverticulum sometimes may be obtained by palpation of the characteristic large fecalith within it or by palpation of the ostium of the diverticulum through the opposite wall of the cecum.

The results after operations performed at Massachusetts General Hospital for cecal diverticulitis show that patients remain asymptomatic. Interestingly enough, no patient has returned with diverticulitis of the left half of the colon.

TRANSVERSE COLON.—Diverticulitis in this segment is rare and generally may be expected to subside spontaneously on conservative therapy. Usually it is associated with widespread diverticulitis of the colon.

DESCENDING COLON.—Although diverticulitis is encountered frequently at the junction of the sigmoid and descending colon, it is much less common higher in the colon below the splenic flexure. However, occasionally large inflammatory masses can occur in this segment. Nearly always sigmoid diverticula are also present. The principles of treatment are similar to those outlined for sigmoid diverticulitis.

INTRAPERITONEAL RECTUM.—This segment of the bowel extends from the peritoneal floor up to the sigmoid flexure. Diverticula are frequently present here as well as in the sigmoid and this segment may be densely adherent from contiguous inflammation in the sigmoid. However, it is generally found that diverticula cease at a level a few centimeters above the peritoneal floor, so that after resection an anastomosis can be made without difficulty.

PROGNOSIS.—The prognosis of patients with diverticulitis is so variable that it is impossible to be dogmatic in so far as any one patient is concerned. From associated data, some general conclusions may be drawn.

PROGNOSIS OF DIVERTICULOSIS

Because the incidence of diverticulosis generally is unknown, the chances of it developing into diverticulitis cannot be predicted. If the incidence of diverticulosis even approaches the 8% level suggested by autopsy studies, it is apparent that

diverticulitis must supervene in but a low percentage of cases or hospitals would be filled with diverticulitis patients. Attempts to correlate the incidence of diverticulosis with prognosis likewise are impossible with our present knowledge.

On the other hand, it is clear that the chances of diverticulosis becoming diverticulitis increase steadily with age. At 55, which is approximately the median for patients now observed with diverticulitis at Massachusetts General Hospital, 4 patients with diverticulosis are seen to 1 with diverticulitis, and at 85, 1 patient with diverticulosis is seen to 2 with diverticulitis.

PROGNOSIS OF DIVERTICULITIS

The prognosis of diverticulitis varies, depending on the type of treatment given. Of the 582 cases admitted to our hospital from 1942 to 1953, medical therapy was used successfully in 443, or 76%. In the remaining cases this method failed, as 3 patients died and the others required surgery for relief. From this data it may be shown that the chances of relief by medical means in a single case of diverticulitis are approximately 3 to 1.

The prognosis after surgical therapy varies greatly, depending on the procedures used. Because of the widespread adoption of resection of the diseased segment, this method has improved tremendously in recent years. From an historic viewpoint, it is interesting to compare prognosis and type of surgery performed. In 1939, Hayden reported operative procedures on 63 patients treated at Massachusetts General Hospital from 1911 to 1936. During that 25-year period, operations were limited essentially to exploratory laparotomy with drainage for perforation, or to a type of defunctioning of the colon. Of the 49 patients who had operations, 28 died, all but 3 from the disease of the colon; 5 had recurrent symptoms and 16 were apparently free of symptoms. In summary, therefore, it can be stated that with inadequate operations, deaths are frequent and that relief from symptoms is obtained in 1 out of 3 cases.

For some time, transverse colostomy was used as the sole method of treating sigmoid diverticulitis. In a report from Massachusetts General Hospital in 1942, in which the prognosis of patients subjected to colostomy was analyzed, Smithwick observed that 25% of patients with diverticulitis did poorly after colostomy. Furthermore, if the colostomy proved

successful, later closure of the colostomy led to recurrence of diverticulitis in 45% of cases. A similar experience was reported by Pemberton, who found that of 29 patients treated by colostomy without bowel resection, 20 had further exacerbations after closure of the colostomy.

The prognosis after resection of the affected segment of the colon, however, is entirely different. Co-workers and I have reported 114 resections, with 3 early unsatisfactory results; these patients were all relieved by a second, more extensive resection. Late recurrence of symptoms is extremely rare. Of 24 patients observed from 4 to 10 years after resection, only 2 patients reported isolated, brief attacks of pain, suggesting recurrent diverticulitis.

Other follow-up studies show resection to be eminently satisfactory. For example, Waugh noted that there were no known recurrences among cases he had subjected to resection.

In summary, diverticulitis may be said to be mild and responsive to medical therapy in 3 out of 4 cases. When the disease is severe, the only operation that gives any measure of relief is segmental resection. Despite the fact that isolated diverticula left proximal to the anastomosis may become inflamed occasionally, this operation does eliminate essentially symptoms of the disease.

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